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EVIDENCE FOR A SINGLE IMPACT AT THE CRETACEOUS-TERTIARY BOUNDARY FROM TRACE ELEMENTS

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Not only meteoritic elements (Ir, Ni, Au, Pt metals), but also some patently non-meteoritic elements (As,Sb) are enriched at the K-T boundary. Strong *et al.*[1] compared 8 enriched elements at 7 K-T sites and found that: (i) All have fairly constant proportions to Ir (within <10x) and (ii) Kilauea — invoked as an example of a volcanic source of Ir by opponents of the impact theory — has too little of 7 of these 8 elements to account for the boundary enrichments We have reexamined the distribution of trace elements at the K-T boundary using a using data from 11 sites for which comprehensive are available.

The meteoritic component can be assessed by first normalizing the data to Ir, the most obviously extraterrestrial element, and then to C1 chondrites (figure 1). The double normalization reduces the concentration range from 11 decades to 5 and also facilitates the identification of meteoritic elements. Only Ni is predominantly meteoritic, although Cr, Co and Fe still have meteoritic components of 5-50%. As, Sb and Zn, on the other hand, have only negligible meteoritic components, and are enriched relative to crustal abundances by 5-50x. It is particularly remarkable that all K-T sites are consistently enriched in these 3 elements by nearly constant factors; the variation at marine sites (circles) is particularly small.

At sites where trace elements have been analyzed in sub-divided samples of boundary clay, namely, Caravaca (SP), Stevns Klint (DK), Flaxbourne River (NZ) and Woodside Creek (NZ), Sb, As and Zn are well correlated with Ir across the boundary (r=0.945 to 0.997) implying a common deposition mechanism. If the impact glass that was the precursor for the K-T boundary clay came from several impacts, then all these impacts would have to have struck sites with the same characteristic enrichment of Zn, As and Sb, and then mix meteorite and target rock in identical proportions, to maintain the observed constancy of the Zn/Ir, As/Ir and Sb/Ir ratios. This is highly improbable, and the only realistic alternative is a single impact.

For a quick survey of source rocks an Sb-Ir plot (figure 2) is useful, as these two elements are most enriched in boundary clay. The principal rock types are well represented on this plot. Boundary clay is unique in being strongly enriched in both elements; mantle rocks match it in Ir but are too low on Sb by 2-3 orders of magnitude, and also have the wrong major element chemistry. Most crustal rocks are too low in both, reemphasizing the obvious fact that an extraterrestrial source is needed for Ir. However, two deep continental igneous rocks have nearly enough Sb, but fail to account for Zn and As, as they contain these elements only at about mean crustal levels (andesite, USGS-AGV-1 and granodiorite, USGS-GSP-1). Considering the limited number of analyses, it would be premature, of course, to rule out igneous rocks as source of Sb, As and Zn. The only other group of rocks measured that could provide sufficient Sb are black shales .

Elemental carbon is also enriched by up to 10^4x in boundary clay from 5 K-T sites[2,3] and is correlated with Ir across the boundary at Woodside Creek[4]. While biomass would appear to be the primary fuel source for this carbon[5] a contribution from a fossil fuel source may be necessary in order to account for the observed C abundance[6]. The strong association between meteorite, fire and target rock implied from the Woodside Creek data can be explained if the target rock itself were a source for both the carbon and chalcophiles. This could be the case if the impact site were an area rich in carbonaceous sediments, such as a deep sedimentary basin on a continental shelf and organic rich shales are known to lose chalcophile elements during combustion[7].

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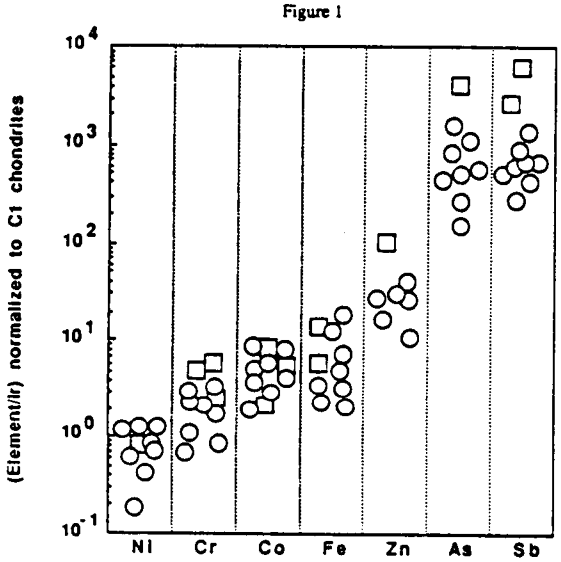
References
[1]Strong C.P., Brooks R.R., Wilson S.M., Reeves R.D., Orth C.J., Mao X., Quintana L.R., and Anders E. (1987) *Geochim. Cosmochim. Acta*, **51**, 2679-2777.
[2]Wolbach W.S., Lewis R.S. and Anders E. (1985) *Science*, **230**, 167-170.
[3]Wolbach W.S., Gilmour I., Anders E., Orth C.J. and Brookes R.R. (1988) *Nature*, submitted.
[4]Wolbach W.S., Anders E. and Orth C.J. (1988) this volume.
[5]Gilmour I. and Guenther F. (1988), this volume.
[6]Gilmour I. Wolbach W.S. and Anders E. (1988), this volume.
[7]Bentor Y.K. *et al.* (1981) *Geochim. Cosmochim. Acta* **45**, 2229-2255.

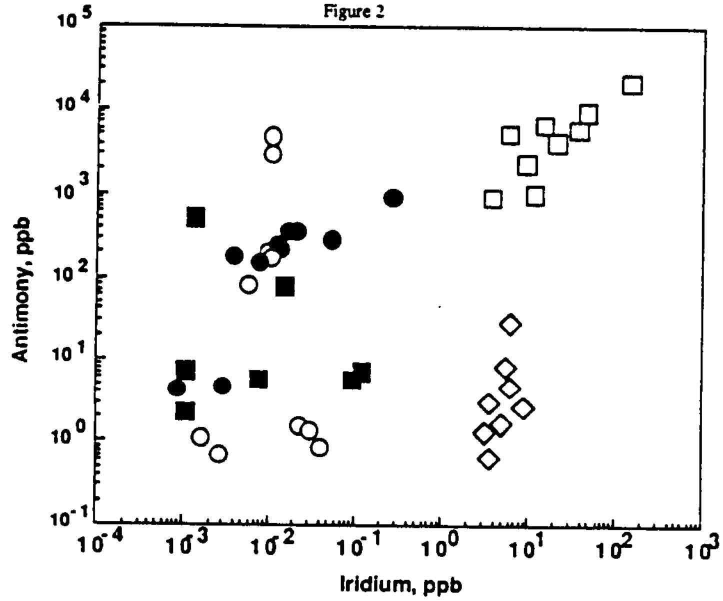
Figure 1



○ Marine sites: Gubbio (IT), Stevns Klint (DK), Caravaca (SP), Zumaya (SP), Flaxbourne River (NZ), Woodside Creek (NZ), DSDP 465A (Pacific)

□ Continental sites: Raton Basin, York Canyon, Sugarite (U.S.)

Figure 2



● Sediments, ○ Continental igneous, ■ M.O.R.B.
□ K-T boundary, ◇ Upper Mantle nodules

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